POWERTRAIN CLUTCH

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to United States Provisional Patent Application No. 60/493,594 filed August 8, 2003, which application is herein expressly incorporated by reference.

TECHNICAL FIELD

[0002] The present invention generally pertains to motor vehicles. More particularly, the present invention pertains to a clutching arrangement for selectively engaging and disengaging a transmission with a source of drive torque. More specifically, but without restriction to the particular embodiment and/or use which is shown and described for purposes of illustration, the present invention relates to a clutching arrangement which electronically engages and disengages a transmission with a source of drive torque in response to predetermined events.

BACKGROUND OF THE INVENTION

[0003] With a conventional manual transmission, an operator controlled clutch pedal is depressed for selectively disengaging the transmission from a source of drive torque (typically the engine) in order to be able to shift gears while the transmission is disengaged. In this manner, damage to the gears of the transmission is avoided. The clutch pedal is used to disengage the clutch, which is basically a friction coupling placed between the engine and the transmission. The components of such an arrangement are subject to wear, including the friction surfaces of the clutch. Furthermore, many drivers consider the necessity of manually depressing a clutch pedal while gear shifting to be unacceptably inconvenient. A manually operated clutch also has the disadvantage that the smoothness of engagement depends upon the skill of the operator. These factors have lead to the widespread use of automatic transmissions that do not require the operation of a clutch pedal. However, the convenience of an automatic transmission comes also with well-known disadvantages in terms of performance, fuel efficiency, emissions, complexity, longevity and costs that are substantially higher than a comparable manual transmission.

[0004] While transmissions have been developed that shift automatically in response to certain predefined events, the difficulty of automatically disengaging and engaging a friction clutch for repeatable smooth performance has achieved limited acceptance. It remains a need in the pertinent art to provide a clutching arrangement that overcomes the operator perceived inconveniences associated with a manual transmission while retaining the noted advantages of a manual transmission.

SUMMARY OF THE INVENTION

[0005] It is an object of the present invention to provide a clutching arrangement and control logic which adapt a manual transmission to provide convenient manual shifting without the need to manually operate a conventional pedal.

[0006] It is another object of the present invention to provide a clutching arrangement and control logic for a manual transmission that provides the driver full control of shifting speeds for desired performance. It will at the same time provide a level of driving convenience and smoothness of operation comparable with an automatic transmission without clutch pedal operation.

[0007] It is an other object of the present invention to provide a clutching arrangement and control logic for a manual transmission that will retain the higher fuel efficiency and lower emissions levels associated with the use of a manual transmission, but will at the same time provide a level of driving convenience comparable with an automatic transmission without clutch pedal operation.

[0008] It is another object of the present invention to provide a clutching arrangement and control logic for a manual transmission that will still provide the simplicity, longevity and reliability of a manual transmission, but will at the same time provide a level of driving convenience comparable with an automatic transmission without clutch pedal operation.

[0009] It is another object of the present invention to provide a clutching arrangement and control logic for a manual transmission that will not depend on human operation for the speed of engagement, but instead

will put the vehicle's computer in control for the speed of engagement, thereby optimizing such engagement speed to avoid too abrupt an engagement which can damage engine, clutch or transmission parts, or too slow an engagement which can slip and damage the friction linings of the clutch as well as provide insufficient vehicle acceleration.

[0010] It is another object of the present invention to provide a clutching arrangement and control logic for a manual transmission that will be free of the wear inherent in conventional friction clutches and therefore will not require service or replacement of friction surfaces or other wear components.

[0011] It is another object of the present invention to provide a clutching arrangement and control logic for a manual transmission that will be operator fool-proof; i.e., it cannot be damaged by the operator's actions or habits (such as resting a foot on the clutch pedal while driving, which can lead to rapid wear and failure in a conventional clutch.)

[0012] It is another object of the present invention to provide a clutching arrangement and control logic for a manual transmission that will improve the performance of transmissions that shift automatically in response to predefined events by providing smooth, controlled and precise engagement of the clutch on a repeatable basis regardless of operating conditions.

[0013] It is another object of the present invention to provide a clutching arrangement and control logic for a manual transmission that includes a synchronizer arrangement that can eliminate the individual synchronizers of each gear set of a conventional transmission.

[0014] It is another object of the present invention to provide a clutching arrangement and control logic for a manual transmission that eliminates the requirement for a torsional dampener that is conventionally incorporated in the clutch plate of a standard dry-friction clutch.

[0015] In one particular form, the present invention provides a clutching arrangement for transferring power from an output shaft of an engine to an input shaft of a manual transmission. The clutching arrangement includes a housing and an electrically controlled clutch mounted

in the housing The clutch selectively couples and uncouples the output shaft and the input shaft. The clutch arrangement further includes a clutch synchronizer disposed between the input shaft and the output shaft for synchronizing a speed of the input shaft with a speed of the output shaft.

[0016] In another form, the present invention provides a clutching arrangement for transferring torque between a first drive member and a second-drive member, the clutching arrangement includes an input assembly for coupling to the first drive member and an output assembly for coupling to the second drive member. The output assembly is selectively coupled to the input assembly. The clutching arrangement further includes a magneto rheological fluid (MRF) disposed between the input assembly and the output assembly. The MRF is operable to normally permit relative rotation between the input assembly and the output assembly and operable upon activation to selectively couple the input assembly and the output assembly.

[0017] In another form, the present invention provides a method of selectively transferring torque between a first member and a second member. The method includes the step of providing a clutching arrangement having an input assembly coupled to the first member and an output assembly coupled to the second member. The clutching arrangement additionally includes MRF disposed between the input assembly and the output assembly. The MRF is operable to normally permit relative rotation between the input assembly and the output assembly and operable upon activation to selectively couple the input assembly and the output assembly. The method further includes the step of activating the MRF to selectively couple the input assembly and the output assembly.

[0018] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

[0019] Additional benefits and advantages of the present invention will become apparent to those skilled in the art to which this invention relates from a reading of the subsequent description of the preferred embodiment and the appended claims, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0021] Figure 1 is a cross-sectional view of a transmission clutch according to the teachings of the present invention.

[0022] Figure 2A is an enlarged cross-sectional view of a portion of Figure 1.

[0023] Figure 2B is an enlarged cross-sectional view of a portion of Figure 1.

[0024] Figure 2C is an enlarged cross-sectional view of a portion of Figure 1.

[0025] Figure 3 is an enlarged cross-sectional view of a portion of Figure 1.

[0026] Figure 4 is a cross-sectional view similar to Figure 1, illustrating an alternate method of connecting a battery to the clutch coils is shown.

DETAILED DESCRIPTION

[0027] With initial reference to Figure 1, a vehicle transmission clutch or clutch assembly with integral synchronizer constructed in accordance with the teachings of an exemplary embodiment of the invention is illustrated and generally identified at reference 10. It will be appreciated that the particular embodiment shown is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0028] With continued reference to Figure 1 and additional reference to Figures 2A-2C, the transmission clutch 10 is illustrated to generally include a flywheel 13 mounted to crankshaft 12 of an internal combustion engine 11. A bell housing 15 of the transmission clutch 10 is

bolted or otherwise suitably attached to the internal combustion engine 11 on the flywheel end and to a manual transmission on an opposite end. Contained within the clutch portion is a small amount of magneto rheological fluid (MRF). The volume of the MRF is sufficient to fill a gap defined by the inside diameter of a clutch stator 17 and the outside diameter of a clutch rotor 26. A plurality of clutch coils 21 are connected in parallel to a slip ring 27. When current from a battery of the vehicle is applied to the coils 21, flux fields 35 are generated and the clutch 10 is capable of transmitting engine torque to the transmission.

[0029] The clutch 10 includes a drive flange 16 which can be constructed of aluminum or other non-magnetic material. The drive flange 16 is bolted or otherwise suitably attached to the flywheel 13. The stator 17 is attached to the drive flange 16 in the embodiment illustrated and may be constructed of low carbon steel. Coil housings 18 and coil covers 20 and 22 are mounted to the outside diameter of the clutch stator 17 and define the cavities that accept the coils 21. The coil housings 18 and coil covers 20 and 22 may be constructed of low carbon steel.

[0030] Spacers 19 are disposed between adjacent housings and covers 20 and 22. The spacers 19 can be constructed of aluminum or other non-magnetic material and serve to keep flux fields 35 from mutual interference. The coils 21, coil housings 18, coil covers 20 and 22 and spacers 19 are all mounted on the clutch stator 17 and secured together by studs and nuts 33 to make an integral sub-assembly. This clutch stator sub-assembly rotates wit the engine flywheel 13. As will be appreciated by those skilled in the art, the total inertia of the flywheel 13 and clutch stator sub-assembly must be controlled within precise limits.

[0031] Multiple coils 21 may be used in particular applications to lower the total area of low carbon steel surrounding the coils and thereby provide proper flux density for a specific clutch torque rating. In this manner, the coils 21 enable the arrangement to meet the total flywheel and stator sub-assembly inertia requirements. A further potential benefit of multiple coils 21 is the reduction of total electrical amperage as compared to a single

coil for the same torque rating. It will be appreciated by those skilled in the art, however, that most applications need only employ a single coil 21.

[0032] The clutch 10 includes a torque tube 28 supported on one end by a bearing 31 mounted in the drive flange 16. On its other end, the torque tube 28 is supported by a bearing 206 in a synchronizer sub-assembly 200. A hub 24 is bolted to a flange integrally formed on the torque tube 28. A rotor 26 is doweled to this hub 24. One end of the torque tube 28 contains an internal spline 36 that mates with a spline on the input shaft of the transmission 14. A cover 25 seals one end of the clutch 10.

[0033] A clutch cover 23 may be constructed of aluminum or other non-magnetic material and is attached to a coil cover 22 by screws or other suitable means. A seal 32 mounts in the inner bore of the clutch cover 23 and seals the other end of the clutch 10. The clutch cover 23 also supports the slip ring 27.

[0034] Particular reference is now made to Figures 2A-2C. The wires from the coils 21 are secured to the slip ring 27 by screws 107. The main body of the slip ring 27 can be plastic. Bronze rings 105 are secured to this body by the screws 107. The stationary housing of the slip ring 27 consists of two brush retainers 102 that are slotted to accept two sets of brushes 104 at 180 degrees and can be plastic. A center ring 101 may be also made of plastic. These three parts are held together by screws 109 attaching then to plastic plates 103. The plastic plates 103 are attached to bearing plate 202 (shown in Figure 3) by screws 110. Springs 108 provide pressure to the brushes 104 for proper seating to the bronze rigs 105. Two sets of brushes 104 are used to reduce amperage flow and thereby their life.

[0035] A Hall sensor 107 is also mounted on the center ring 101. A magnetic target 106 is mounted in the main body of the slip ring 27. Engine speed and thus input speed to the clutch 10 is already monitored by the engine control electronics in a conventional manner. The Hall sensor 107 monitors the output speed of the clutch 10 that is used for several control functions as described below.

[0036] With particular reference to Figure 3, an enlarged cross-sectional view of the synchronizer 200 is provided. In the embodiment illustrated, the synchronizer 200 is a brake-type assembly that uses the same magneto rheological fluid (MRF) technology as the clutch 10. It will be appreciated by those skilled in the art, however, that a conventional friction-type synchronizer arrangement may be alternatively used within the scope of the present invention. MR fluid is added to this section of the assembly 10 through a port 211. The amount of MR fluid used is sufficient to fill the annulus gap defined by an inside diameter of a brake stator 205 and the outside diameter of a brake rotor 201.

[0037] The stator 205 contains a coil 204. The stator 205, an intermediate plate 203 and the brake rotor 201 can be made of low carbon steel. The brake rotor 201 is conventionally secured to the torque tube 28 by a key and retaining ring. The brake rotor 205, the intermediate plate 203 and the bearing plate 202 are held together by screws 213. O-rings 207, 208 and 209 provide static seals to retain the MR fluid within the synchronizer 200. The housing 30 is part of the transmission 14 and contains a bearing for the transmission input shaft 29. The coil 204 provides braking torque generally proportional to the amount of current applied. As noted above, a synchronizer based on conventional dry-friction technology can alternatively perform the same function as a MR fluid technology synchronizer as just described. Such conventional technology would, however, be less durable.

[0038] Particular reference is again made to Figure 1 to explain the sequence of assembly of the present clutch 10 to a vehicle. The flywheel 13 is first assembled onto the engine crankshaft. The bell housing 15 is mounted to the transmission 14. All other elements of the present invention may be pre-assembled as an integral unit. This integral unit is assembled onto the flywheel 13 and secured by screws. The transmission shaft 29 (which is an integral part of the transmission) is inserted into the torque tube 28 and guided as its spline enters the internal spline of the torque tube 28. The pilot diameter of the brake stator 205 contacts the housing 30 of the transmission 14. This engagement can be observed through holes 35 in the

bell housing 15. The bell housing 15 is now attached to the engine 11. Two screws 34 are used to secure the brake stator 205 to the housing 30. The holes 35 and a wrench or other suitable tool are used for this purpose. The screws 34 are threaded into the housing 30 and may have a cone-shaped end that mates with a conical cavity in the brake stator 205.

[0039] Reference will now be made to the alternative construction of Figure 4. In certain applications, it may be desirable to conduct the electric current to the clutch coils 21 without physical contact between mechanical parts (and therefore subject the parts to wear). As a non-wear alternative to the slip ring arrangement described above, a rotary transformer 300 such as shown in Figure 4 may be incorporated for delivering electric current to the clutch coils 21. The rotary transformer 300 includes a coil 50 and its housing 52 that rotate with the clutch coils 21. The rotary transformer 300 further includes a coil 51 and its housing 53 that are stationary. Additionally, the rotary transformer 300 has other electronic components not shown but conventional in the art. The coil 50 is connected to the clutch coils 21 and the coil 51 is connected to the battery of the vehicle. Electrical current is transmitted from the battery to the clutch coils 21 by the inductive action of the coils 50 and 51.

[0040] The torque transmitted by the clutch 10 is generally proportional to the applied current to the coils 21. If enough current is applied to these coils 21, there is no slippage between input and output of the clutch. In other words, the transmission input shaft 29 rotates at exactly the same speed as the flywheel 13. It will be appreciated by those skilled in the art that the current to the coils 21 may be modulated.

[0041] Conventional dry-friction automotive clutches incorporate a torsion-dampening device. One function of this device is to soften the so-called "rooster-tail" or rapid torque increase during the transition from dynamic to static operation. The clutch 10 described herein does not exhibit such torque peaking since the MRF transmits the torque. The other function of the torsion dampener is to soften road-induced shocks. Conventional dry-

friction automotive clutches are engaged by springs of such force that they are rated at approximately twice the actual torque required.

[0042] The clutch torque of the present invention is kept just above the actual torque required for the "real-time" operating condition. In this regard, a Hall sensor 107 continuously monitors the output speed of the clutch 10 and compares it to the engine speed. During acceleration of the vehicle, the current to the clutch coils 21 is increased by the an engine control module to just above "no-slip". Sensors conventionally installed on the vehicle for other purposes sense when acceleration is completed and the clutch coil current is reduced until the output speed is just under the input speed and then increased slightly for "no-slip". With clutch torque just above required torque, the clutch 10 is permitted to slip slightly when road-induced shock occurs and thereby eliminates the need for a separate torsion-dampening device.

[0043] Current is normally applied to the clutch coils 21 when the engine 14 is running except when the transmission 14 is in a neutral position. Depressing the brake pedal also disconnects current to the coils 21. The clutch 10 is disengaged for shifting between gears in the transmission by opening a switch in the electrical leads to the brushes 104. This clutch-disengage switch may be incorporated in the transmission shift lever and can be held depressed during shifting. The clutch control module knows the present ratio when the clutch is disengaged for shifting. Using this information and the vehicle speed, the module calculates the required speed of the transmission input shaft 29. Either the clutch coils 21 are energized if the speed is too slow or brake coil 204 if too fast. This reduces the wear and tear on the synchronizers built into each gear ratio of the transmission and in fact, can completely eliminate them. After shifting is complete, the clutch-disengage switch is released.

[0044] Each shift command from the driver generates an electrical signal to engage or disengage the clutch 10. The electrical signal also activates the clutch synchronizer 200 to allow a smooth shift of the manual

transmission. The vehicle computer coordinates and synchronizes the total process.

[0045] An algorithm is resident in the engine control module or clutch control module that controls the rate current is applied to the clutch coils 21 for a smooth engagement. Optionally, this algorithm includes provisions for the ability of the vehicle operator to change the speed of clutch engagement to various defined rates. For example, a "sports" version would have aggressive, but smooth clutch engagement while a "cruise" version would have less aggressive engagement. The algorithm automatically controls torque just above the torque required to drive the output of the clutch 10 at the same speed as the engine speed under all operating conditions. Slight clutch slippage cushions any road shock, thereby eliminating the need for other mechanism, such as dampers. The algorithm automatically increases the clutch torque smoothly to provide proper acceleration and simultaneously meet the previously described conditions in which torque is just above the required torque. By automatically adjusting the speed of the driving gear in the engine to the speed of the driven gear in the transmission, engagement of gears is smooth and without clashing of teeth. Synchronization is accomplished by selectively energizing the coils of the clutch 10 or the coil of the synchronizer brake. In certain applications, it may be desirable for the algorithm to provide for vehicle creep when the engine is operating at idle speed so as to create further driving convenience in stop and go traffic.

[0046] The electronic clutching of the present invention eliminates the need for a clutch pedal. Depressing and releasing a clutch pedal many times in heavy urban traffic is tiring and an important reason for the widespread use of automatic transmissions. If a clutch pedal is desired because of operator preference, the usual levers and links that connect it to the clutch are eliminated. The pedal only operates a switch. A light spring is also incorporated to give the operator some "feel" in its operation.

[0047] An alternative for automatic transmissions is the electronic shifted manual transmission. These offer the convenience of automatic

transmissions with the added benefits of better gas mileage and better durability. These electronically shifted manual transmissions have used dry-friction clutches – the same type used on a manually shifted transmission. They have been modified to be electrically operated using various schemes but the inherent wear and instability of the dry-friction technology sacrifice the performance of electronic shifted manual transmissions and have thus limited their acceptance. The mating of the present invention with these transmissions will significantly improve the performance and durability of these systems. The electronic shifted manual transmissions can be programmed to respond automatically to specific and changing operating conditions to make them competitive with the automotive transmissions. Alternatively, manually selected switches such as paddles on the steering wheel can initiate electronic shifting. The present invention enhances the performance of either control strategy.

[0048] The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.